Final Basis of Design Report

Buffalo River Area of Concern
Buffalo, New York

Volume 2

Final Design for Habitat Restoration

WA No. 146-RDRD-1524/Contract No. EP-S5-06-01

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CH2MHILL®

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Acronyms and Abbreviations

AOC	area of concern
BMP	best management practice
BODR	Basis of Design Report
BUDC	Buffalo Urban Development Corporation
CAA	Clean Air Act
CDF	confined disposal facility
CFR	*Code of Federal Regulations*
CSO	combined sewer overflow
CWA	Clean Water Act
ECDP	Erie County Department of Planning
EEE	*Ecology Engineering Evaluation*
EEEPC	Ecology and Environment Engineering, P.C.
EV	emergent vegetation
FS	feasibility study
ft^2	square feet
FWPCA	Federal Water Pollution Control Act
GLLA	Great Lakes Legacy Act
GLNPO	Great Lakes National Program Office
IGLD	International Great Lakes Datum
LDB	left descending bank
LUNKERS	Little Underwater Neighborhood Keepers Encompassing Rheotactic Salmonids
LWD	low water datum
m/s	meters per second
NFTA	Niagara Frontier Transportation Authority
NHPA	National Historic Preservation Act
NYCRR	New York Code, Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCT	project coordination team
RDB	right descending bank
SAV	submerged aquatic vegetation
SEQR	State Environmental Quality Review
SPDES	State Pollutant Discharge Elimination System
SRIR	*Sediment Remedial Investigation Report*
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

USC	United States Code
USEPA	U.S. Environmental Protection Agency
yd^3	cubic yard

SECTION 1

Introduction

This final basis of design report (BODR) Volume 2 for habitat restoration in the Buffalo River Area of Concern (AOC) has been prepared for the U.S. Environmental Protection Agency (USEPA) under CH2M HILL's Remedial Action Contract No. EP-S5-06-01. Habitat restoration is to be conducted following the sediment remediation activities described in BODR Volume 1. This BODR Volume 2 includes the habitat restoration elements specified in the Statement of Work for Work Assignment No. 146-RDRD-1524 and is divided into the following sections:

- Section 1—Introduction
- Section 2—Habitat Restoration Design
- Section 3—Habitat Restoration Design Implementation
- Section 4—Compliance with Applicable Requirements
- Section 5—Performance Monitoring and Operations and Maintenance Requirements
- Section 6—Construction Schedule
- Section 7—Cost Estimate
- Section 8—Biddability and Constructability Review
- Section 9—References
- Tables
- Figures

Combined appendixes for both volumes provide supplemental information integral to the design of the selected sediment remediation remedy and habitat restoration. The appendixes consist of the following:

- Appendix A—Summary Data Tables and Figures from Investigations in the Buffalo River AOC
- Appendix B—Final Design Drawings
- Appendix C—Specifications
- Appendix D—Design Calculations
- Appendix E—Construction Schedule
- Appendix F— Permits
- Appendix G—Compensation Schedule
- Appendix H—Monitoring Plans
- Appendix I—USACE Reports
- Appendix J—Application for CDF Use
- Appendix K—Critical Structure Approach

Multiple agencies and organizations have been involved in the investigation of and remedial planning for the Buffalo River AOC, including USEPA's Great Lakes National Program Office (GLNPO), the New York State Department of Environmental Conservation (NYSDEC), Buffalo Niagara Riverkeeper, the U.S. Army Corps of Engineers (USACE), the U.S. Fish and Wildlife Service (USFWS), Honeywell International, Inc., the City of Buffalo, and their respective consultants. Collectively, the members comprise the project coordination team (PCT), and project decisions are made through discussions with the entire team.

Under the Great Lakes Restoration Initiative, a multi-year, multi-agency initiative to restore the Great Lakes, the USACE completed dredging of the navigational channel in 2011. The remaining remedial dredging activities under the USEPA Great Lakes Legacy Act (GLLA) contract is expected to commence in 2013 and will include sediment remediation activities described in Volume 1 and habitat restoration activities discussed in this Volume 2 portion of the BODR.

The habitat restoration activities will be completed at Riverbend, Buffalo Color Peninsula, Katherine Street Peninsula, Ohio Street Shoreline, and the City Ship Canal sites. The sites will be restored by replacing and augmenting aquatic habitat impacted by dredging or capping as well as enhancing site aquatic zones. The habitat restoration efforts at the City Ship Canal and Katherine Street sites will be used to mitigate environmental impacts from the dredging activities.

1.1 Background

The Buffalo River AOC is located in the City of Buffalo in western New York State (Figure 1). The river flows from the east and discharges into Lake Erie near the head of the Niagara River. A portion of the Buffalo River is designated as a federal navigation channel and is maintained by the USACE at a depth of 22 feet below low water datum (LWD). The AOC includes the entire 1.4-mile stretch of the City Ship Canal (Ship Canal) that adjoins the river just upstream of the river confluence with Lake Erie, and extends upstream approximately 6.2 miles. The AOC is regarded as the impact area and is characterized by historically heavy industrial, commercial and public development in the midst of a large municipality. Since the early 1800s, municipal and industrial waste has been disposed of in the Buffalo River, including pollution from grain milling and manufacturing industries along the shoreline. According to the USACE, the pollution problems were compounded with the widening and deepening of the river for navigation, which increased hydraulic residence time and sedimentation (USACE 2010a).

Presently, the sources of contamination in the AOC are primarily from the sediments and non-point sources in the Buffalo River Watershed. The Buffalo River sediments have been impaired by past industrial and municipal discharges and disposal of wastes that have resulted in elevated levels of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, and various metals.

From 1998 through 2010, GLNPO, in coordination with other federal, state, and local partners, completed a variety of remedial investigations, planning, and feasibility-level studies to evaluate the impacts of contaminated sediments on the aquatic system and determine an appropriate approach to remediating contaminated sediments within the Buffalo River AOC. The sediment investigations are discussed in Volume 1 of the BODR and select data and figures from previous investigations are provided in Appendix A. In December 2010, a draft final *Feasibility Study for the Buffalo River* report (ENVIRON et al. 2010) was released to the public for comment. The feasibility study (FS) report presents the evaluation of dredging, capping, and habitat restoration technologies that would address the contaminated sediment.

Additional investigations were conducted in August 2010 to address the data needs related to the sediment remediation alternatives and to support the habitat restoration design. Investigation activities also included surveying the critical structures and shorelines of properties that may be impacted by the project. Select data from the investigations are provided in Appendix A.

The USACE Buffalo District performs annual surveys and maintains the federal navigational channel as identified in Figures 2 and 3. In order to maintain the authorized depth of 22 feet below LWD, approximately 140,000 cubic yards (yd^3) of sediment is typically dredged on average every 2 years. In 2011, USACE dredged 452,093 yd^3 of sediment from the federal navigation channel in advance of the environmental dredging described in BODR Volume 1 (see Figure 4 in BODR Volume 1 for USACE dredge areas). In addition, between 2011 and 2012, the USACE dredged a total of 97,539 yd^3 outside of the GLLA project boundaries for regular operation and maintenance purposes (USACE 2012).

The preferred sediment remedy as described in the FS report (ENIVIRON et al. 2010a) and presented in the project agreement, consists of sediment removal by mechanical dredging, capping of contaminated sediment where removal of sediment could compromise the stability of shoreline structures, and aquatic habitat restoration upon completion of the dredging activities. Approximately 412,000 yd^3 of contaminated sediment from the Buffalo River and approximately 50,000 yd^3 of sediment from the Ship Canal will be mechanically dredged and disposed of at the existing USACE confined disposal facility (CDF) No. 4, which was specifically designed for the management and disposal of the Buffalo River sediments. USACE's CDF No. 4 is located in the outer Buffalo Harbor adjacent to the south entrance channel to the harbor (approximately 3 miles from the downstream end of the project area). USACE used the CDF for the disposal of sediments from its dredging activities completed in 2011 and 2012.

The contaminated sediments at the southern end of the Ship Canal (beyond the limits of federal navigational channel) exist in a low-energy environment that is not susceptible to sediment scour from overlying flow, ice events, or navigational dredging. Approximately 290,000 square feet (ft^2) of sediment at the southern end of the Ship Canal will be capped to isolate contaminants and provide a clean sediment surface and an appropriate substrate for habitat restoration in this part of the AOC. The area to be capped in the Ship Canal is identified on Figure 2.

A bathymetric survey will be conducted by the Contractor following the dredging, to confirm dredge cut depths and following capping activities to confirm adequate coverage and cap thickness. Additional information regarding sediment remediation activities is provided in BODR Volume 1, which describes the sediment remediation.

Following sediment remediation activities, habitat restoration will be conducted by the selected Contractor at five restoration sites to fulfill the remedial action objective to "implement a remedy compatible with the Buffalo River Advisory Committee's goal of protecting and restoring habitat and supporting wildlife" (ENVIRON et al. 2010). The in-water portion of the habitat restoration work on the City Ship Canal and Katherine Street Peninsula is considered to be the portion of the project used to mitigate environmental impacts from the dredging activities.

1.2 Habitat Restoration Sites

Initially six restoration sites were identified and selected by the PCT Habitat Subgroup including the Riverbend, Buffalo Color Peninsula, Katherine Street Peninsula, Ohio Street Shoreline, Kelly Island, and the City Ship Canal sites. The Kelly Island site was dropped after it was determined that dredging operations in this area would be confined to the navigational channel and that no direct replacement of the habitat related to the GLLA project would be needed. Each of the remaining five sites selected for habitat restoration and their context within the Buffalo River AOC are described in the following sections.

The PCT Habitat Subgroup also identified multiple restoration alternatives for each site. Restoration alternatives for each site were selected by applying screening and scoring criteria. The proposed boundaries and range of alternatives are summarized in the *Ecology Engineering Evaluation* (EEE) *Report* (ENVIRON and MACTEC 2010), an appendix to the FS report (ENVIRON et al. 2010). Two restoration sites have been expanded beyond the initial EEE report boundaries: the Ohio Street Shoreline site to include the inlet and downstream property and the Katherine Street Peninsula site to include the downstream portion. The restoration site boundaries are presented in Figures 2 and 3.

1.2.1 Riverbend

The Riverbend site is the farthest upstream of the five selected restoration sites. The site occupies 5,452 feet of shoreline and the adjacent near-shore area on the left descending bank (LDB) and is divided by the South Park Bridge (Drawings EH-1 and EH-2, Appendix B). The shoreline within the Riverbend restoration project area is variable. Along the upstream half of the project area, it is classified as stone, concrete cap, or natural cover. Riparian vegetation is present along portions of the area. The shoreline along the downstream half consists of natural cover, old timber pilings, a concrete cap, and an extensive retaining structure along the most downstream portion of the site (ENVIRON et al. 2009). Little, if any, riparian vegetation is present along this downstream half of the project area.

1.2.2 Buffalo Color Peninsula

The Buffalo Color Peninsula site is located on the right descending bank (RDB) across from the lower portion of the Riverbend site and extends for 2,883 feet between the abandoned Niagara Frontier Transportation Authority (NFTA) half bridge and the active CSX railroad bridge. (Drawing EH-2, Appendix B). The habitat restoration site is the location of previous environmental remedial efforts, including the construction of a subsurface slurry wall around the perimeter of the site. During construction, additional waste material was identified outside of the slurry wall along a 500-foot length of the downstream shoreline of the site. In order to preserve the integrity of the slurry wall, approximately 4,000 yd^3 of the waste material immediately adjacent to the slurry wall was left in place (Parsons Engineering Science, Inc. [Parsons] 1998). The material was later capped with a base layer of sand to stabilize side slopes, followed by a geotextile layer and then a surface layer of shot rock and/or riprap (Parsons 2003).

The upland portion of the restoration site is currently mowed grass with uniform riprap banks that contain a mix of native vegetation and invasive plant species. Vegetation planted in the riprap is not maintained and consists of shrubs and herbaceous species, with some smaller trees.

1.2.3 Katherine Street Peninsula

The Katherine Street Peninsula site includes 1,644 feet of shoreline on the RDB along the southeastern corner of the Katherine Street Peninsula. The river bank is steepest at the northern portion of the shoreline, where the navigation channel is approximately 50 feet from the shore and the bank slope is estimated to approach a 2.5:1 (horizontal:vertical) slope. The shoreline becomes considerably shallower at the southeastern corner of the peninsula, where the navigation channel is almost 150 feet from the shoreline and the bank slope is estimated to be closer to a 5:1 slope. River flow rates around the central portion of the site are predicted to be low relative to the areas immediately upstream and downstream due to its location opposite the Blue Water Tower Turning Basin (ENVIRON et al. 2009). The majority of the restoration area comprises vegetated river bank that is generally abandoned industrial property, with the exception of the most upstream portion, where a metal fabricating facility has a small boat ramp and dock (Drawing EH-3, Appendix B).

1.2.4 Ohio Street Shoreline

The boundaries of the Ohio Street Shoreline restoration site extends approximately 1,216 feet along the RDB shoreline and includes a NYSDEC park with a small boat launch, an inlet area that contains a combined sewer overflow (CSO), and a downstream portion currently occupied by a local rowing club. The majority of the park portion of the restoration area includes naturally sloped shorelines, with a few mature trees that provide some shade to the river (Drawing EH-4, Appendix B). This area of the site is characterized by a vegetated riparian zone of trees and shrubs, with mowed grass on the upper park terrace and scattered park amenities. The CSO is located immediately downstream from the park and is at the head of an old off-channel basin inlet. The banks of the inlet are vertical concrete walls with a narrow riparian zone less than 5 to 10 feet and adjacent rubble slope on the northern portion of the site. The inlet area will not be considered for habitat restoration area due to concerns the CSO flow will negatively impact any plantings.

The downstream portion of the site, which is actively used by a local rowing club, has a small boat launch and floating dock. The shoreline of the furthest downstream portion of the site consists of an existing sheet pile wall.

1.2.5 City Ship Canal

The City Ship Canal is a man-made, dead-end canal originally built in the mid-1800s to provide additional mooring for ships. The restoration site is the southern portion (head) of the Ship Canal and includes 4,042 feet of shoreline on both sides of the canal (Drawing EH-5, Appendix B). Currently, there is no large ship traffic in this portion of the canal, where the restoration site is located, as the area is outside of the authorized navigation channel maintained by USACE. The head of the Ship Canal is bordered by naturally sloped shoreline with shrubby and herbaceous riparian vegetation. Portions of the naturalized shoreline are scattered with concrete coating, debris, rubble, and scrap. Other portions consist of two existing sheet piling walls and a longer, partially deteriorating concrete bulkhead. There are numerous areas of piling along the shorelines, particularly in the outer half of the restoration site, and a metal structure is in the water in the northwest portion of the site. Riparian vegetation extends beyond the top of the canal banks only in limited locations due to the vegetation clearing practices used to maintain the adjacent railroad tracks. The distance to the railroad tracks from the site boundary varies. On average, the tracks are located approximately 30 feet from the boundary of the City Ship Canal restoration site.

1.3 Land Use/Ownership

Habitat restoration activities will provide benefit by improving the shoreline of the Buffalo River, which is owned by both private and public entities. The City of Buffalo owns the property within the footprint of the river (Phillips Lytle 2011).

As shoreline structures and future use will be affected by the sediment remediation and restoration activities, there is ongoing coordination with landowners of parcels proposed for restoration. The preliminary design was presented to the majority of the landowners for their initial concurrence and input. Upon completion of the final design, access agreements will be established for the construction and easements as applicable. Property ownership information and locations of structures are presented in BODR Volume 1. Habitat restoration activities are not expected to negatively impact the stability of shoreline structures, but are intended to enhance existing areas not currently slated

for development. Coordination with the habitat restoration property owners will continue so that the restoration complements the property owner's long-term plans.

The three property owners of the Riverbend site include the Riverbend, LLC, the City of Buffalo, and the Buffalo Urban Development Corporation (BUDC). The properties along the project area shoreline are currently vacant (Erie County Department of Planning [ECDP] 2010). A Buffalo Niagara Riverkeeper shoreline restoration project will integrate the restoration activities proposed in this BODR.

The Buffalo Color Peninsula site is comprised of two properties, owned by South Buffalo Development, LLC, and NFTA. The South Buffalo Development, LLC, owns the majority of the site. Its land is vacant (ECDP 2010) and is managed by The OSC Group, which is amenable to restoration activities along the banks. The NFTA property is also listed as vacant, but contains the remnant of a bridge that crosses the Buffalo River. The bridge defines the upstream boundary of the restoration site.

There are four property owners at the Katherine Street Peninsula site. From east to west, they include Stimm Associates, Richard Sikorski, the City of Buffalo, and Henry Olrogge. The existing land use on three of the parcels is vacant (ECDP 2010). The central portion and bulk of the site is owned by the City of Buffalo and includes a high-voltage transmission tower on the upland portion adjacent to the restoration area. The remaining portions are owned by private individuals or corporations (Richard Sikorski, Stimm Associates, and Henry Olrogge). Mr. Sikorski is intending to redevelop the property in the future, but is amenable to restoration along the banks and in the adjacent riverbed. Stimm Associates were not amenable to restoration on this property; therefore, proposed work has been removed from the project area. The in-water features are still planned adjacent to a portion of the parcel. The part of the site owned by Henry Olrogge is slated for water-dependent redevelopment, and, as such, the current design reflects the proposed development.

There are three different parcels at the Ohio Street Shoreline site. From south to north, the parcels include the Great Lakes Paper Company, NYSDEC, and a parcel jointly owned by Carl Paladino and Louis Magnano. The property owned by Carl Paladino and Louis Magnano has a commercial existing land use, which is currently occupied by a local rowing club, while the NYSDEC property is a park and Great Lakes Paper Company parcel is considered vacant (ECDP 2010). The Great Lakes Paper Company is immediately upstream of the restoration site boundaries.

The parcels along the shoreline of the cap area of the City Ship Canal are all owned by CSX. The northwestern parcel along the habitat restoration area has the existing land use of community services/public services, while the other three parcels have no data (ECDP 2010). Landowner willingness for restoration activities is currently being explored.

SECTION 2

Habitat Restoration Design

Section 2 summarizes the habitat restoration design elements and the associated assumptions (Section 2.1) and technical parameters (Section 2.2) upon which the design elements are based. Section 2.3 describes the habitat restoration design by technique, and Section 2.4 discusses the design by site.

2.1 Design Considerations

The following list provides a framework for the choice of restoration techniques and applications at each site and has been developed in coordination with the PCT Habitat Subgroup.

- Restoration site locations selected by the PCT Habitat Subgroup that are included in this design include the Riverbend, Buffalo Color Peninsula, Katherine Street Peninsula, Ohio Street Shoreline, and the City Ship Canal.
- No specific target species have been identified as part of the restoration process. The intent is a general restoration of habitat with the goal of restoring, enhancing, and improving existing habitat structure and functions in aquatic and emergent zones instead of targeting habitat requirements of specific native species. Design elements were selected to enhance the existing habitat in the Buffalo River based on existing conditions at the selected restoration sites.
- The habitat restoration design includes in-water activities below elevation 571 feet International Great Lakes Datum [IGLD]. This elevation was selected as the average water surface elevation for the habitat restoration activities and is based on the data collected from the Lake Erie buoy at the mouth of the Buffalo River. The elevation was used in the hydraulic modeling included in the FS report (ENVIRON et al. 2010), and given the controlling nature of Lake Erie on river water surface elevation, is a reasonable choice for an average river water surface elevation. Elevation 571 feet IGLD was used primarily in the design to determine appropriate elevations for various planting types at the restoration sites. The average water surface elevation accounts for the natural variation (lake levels, seiche/wind events, etc.) in the water elevations on a long-term scale, and has been used successfully at other GLLA restoration projects (for instance, Ashtabula River, Ohio).
- The primary design goal is to be able to identify and implement feasible restoration techniques that will result in an improvement of habitat relative to existing conditions, rather than adhering to a calculated mitigation ratio.
- Long-term maintenance of structures and restoration areas is not part of the GLLA-funded remedial activities, but the design incorporates efforts to encourage sustainability over the long-term.
- No permanent restoration activities will occur within the navigation channel.
- Habitat restoration activities will take place following planned sediment removal. No sediment removal will occur in the restoration area in the City Ship Canal, which will be capped before habitat restoration will be performed.
- Section 204 of the Water Resources Development Act of 1992, as amended, authorizes USACE to implement projects for the protection, restoration and creation of aquatic and ecologically related habitats, including wetlands, or to reduce storm damage to property, in connection with dredging for the construction or operations and maintenance of an existing authorized Federal navigation channels. It was assumed that the beneficial use material from the USACE 204 implementation is not available for restoration purposes. If available, the suitability of material and permitting requirements will need to be determined prior to the construction phase. USACE will work with NYSDEC to ensure chemical characterization will meet state requirements.
- As many pilings as practical will be retained during the dredging activities and have been incorporated into the dredging design drawings.

2.2 Site Data—Existing Conditions

Data collected during recent field investigations are summarized in the habitat restoration field summary report (CH2M HILL and EEEPC 2011a). Existing habitat data were compiled from available sources and field investigations,

and evaluated in the habitat restoration data evaluation report (CH2M HILL and EEEPC 2011b). Detailed descriptions of the hydrodynamic conditions, and existing physical and biological conditions, such as shoreline structures, vegetation types, and soil and sediment properties, are provided for each restoration site.

Data pertaining to Buffalo River hydrodynamic conditions, such as velocities and forces on the channel beds, are essential to the design of stable habitat restoration techniques. The primary sources of data include previous site investigations and modeling efforts performed by ENVIRON, MACTEC, and LimnoTech, which are summarized in the FS report (ENVIRON et al. 2010), the *Sediment Remedial Investigation Report for the Buffalo River* (SRIR; ENVIRON et al. 2009), and the *Assessment of Anticipated Sedimentation Rates for Lower Buffalo River* memorandum (LimnoTech 2011). The documents provide the details of data collection and model evaluations performed to assess the hydrodynamic conditions within the Buffalo River AOC that affect channel stability and sediment transport. The hydrodynamic conditions of the Buffalo River were modeled using varying flow conditions to demonstrate the flood elevations and velocity and sheer stress distributions over a range of flow and seiche conditions (ENVIRON et al. 2009 and 2010). Existing hydrodynamic data are summarized and evaluated in the habitat restoration data evaluation report (CH2M HILL and EEEPC 2011b).

The Buffalo River watershed covers about 445 square miles and drains from parts of Buffalo and Wyoming Counties in western New York State, including three major sub-watersheds: Cayuga, Buffalo, and Cazenovia Creeks (Figure 1). The Buffalo River is a tributary to Lake Erie. The hydrodynamics of the Buffalo River are influenced by both the upstream watershed hydrology and the Lake Erie seiche events. The Lake Erie seiche events are defined as periodic oscillations in lake level, set in motion by atmospheric pressure changes instigated by climate and weather patterns. The intervals (or periods) between seiche peaks along Lake Erie have been observed to range from minutes to more than 8 hours. One or more seiche events following a storm surge have been observed to cause repeated flooding of low-lying property within the AOC, as observed during a large Lake Erie seiche event on January 30, 2008, which raised the water surface elevation of the lake by over 9 feet to an elevation of 580.3 feet relative to the IGLD. The average water surface elevation based on historical monthly averages is about 571 feet IGLD. Small seiche events (that cause water surface increases of less than 1 foot) are an everyday occurrence in Lake Erie.

As part of the habitat restoration design process, the existing hydrodynamic data were reviewed, and design flows were selected to obtain appropriate design velocities and shear stresses to be used in design calculations. Typically, restoration design applications consider bankfull flow as the relevant design flow as it has the most potential for transporting sediment and instigating channel forming processes. Bankfull flows are reported to occur every 1 to 2 years on the Buffalo River watershed tributaries; however, in the case of the AOC, the flows are unlikely to be the controlling design storm as channel modifications and dredging have been performed to ensure the channel contains even large wet weather flows to reduce impacts from flooding (U.S. Geological Survey 2010). Following discussions with the Buffalo River PCT team, the 10-year flood event was selected as the appropriate design storm to assess critical design velocities and shear stresses for the upstream restoration sites (Riverbend, Buffalo Color Peninsula, and Katherine Street Peninsula). The maximum velocities and shear stresses were identified in the habitat restoration data evaluation report (CH2M HILL and EEEPC 2011b) and originally determined in the SRIR (ENVIRON et al. 2009). The 10-year seiche scenario was determined to be the appropriate design storm for the downstream restoration sites (Ohio Street Shoreline and City Ship Canal); however, the only existing seiche data is for a less than 1-year return interval that occurred during model calibration fieldwork by LimnoTech. Therefore, design velocities and shear stresses corresponding to the 10-year seiche scenario were estimated using the ratio of the maximum velocities for the 10-year flood event and the maximum velocities for the 1-year flood event. The resultant value was 2.5 and it was rounded up to 3 to be conservative. The 10-year seiche velocity was calculated by applying the ratio of 3.0 to the 1-year seiche velocities and shear stresses originally identified in the SRIR. Table 1 summarizes the selected design flows, and corresponding design velocities and shear stresses, for each restoration site. Scour and sediment deposition potential are also noted as design considerations. Additional information for the design flows and scour areas can be found in the habitat restoration data evaluation report (CH2M HILL and EEEPC 2011b).

In October 2011, LimnoTech prepared an assessment of the hydrodynamic and sediment transport conditions in the Buffalo River, with an emphasis on predicted sedimentation rates at the habitat restoration sites located in the Buffalo River (LimnoTech 2011). The assessment did not evaluate the sedimentation rates within the City Ship Canal. According to the assessment, sediment deposition rates are expected to be minimal at Ohio Street Shoreline,

relatively higher at Katherine Street Peninsula, and moderate at Riverbend and Buffalo Color Peninsula. The deposited sediments are likely to be coarser upstream and more influenced by bedload, and finer downstream with the potential influence of lake fines at the most downstream areas. The predicted trends are due to a combination of factors including greater stream energy upstream, flow velocities and bottom stresses that are variable but generally low to moderate in the middle reaches, higher velocities in the narrower reach between river miles 1.0 and 2.0, and downstream interactions with the lake and lake-associated fine sediment. The assessment also included a summary of shoaling rates, hydrodynamic modeling results, and particle size distribution data.

2.3 Habitat Restoration Techniques

The following sections provide descriptions and associated details of each of the proposed restoration techniques selected by the PCT Habitat Subgroup. The design for each site will combine the various techniques to increase the overall efficacy of habitat restoration. The elevations stated in the following sections are intended to illustrate the design concept and should be considered approximate.

2.3.1 In-water Techniques

2.3.1.1 In-water Backfill

This technique will be implemented in locations where emergent vegetation (EV) and submerged aquatic vegetation (SAV) beds are to be reestablished or augmented following dredging. For construction purposes, backfill will be placed at a 3:1 (horizontal:vertical) slope or flatter from the edge of the navigation channel towards the shoreline up to elevation 563 feet IGLD. The slope will then vary based on site-specific conditions (3:1 or flatter) from elevation 563 to 571 feet (571 feet referred to as the average water surface elevation). SAV will be planted between elevations 563 and 569 feet to provide sufficient phototropic light availability. The elevations correspond to water depths of 2 to 8 feet, which were observed during field investigations to be the water depths of existing SAV growth throughout much of the river corridor. Two stacked coir logs will be placed at elevation 569 feet to provide a wave-break for EV plantings. EV will be planted between elevations 569 and 571 feet, corresponding with 0 to 2 feet of water depth. The water depths favor emergent vegetation growth and are intended to be deep enough to support native species and preclude the establishment of invasive EV, such as common reed (*Phragmites australis*).

The technique assumes in-water backfill will be placed in the fall and will be allowed to settle over the winter. Prior to spring planting of both SAV and EV, a bathymetric survey will be performed to verify the final slope elevations and additional fill will be placed as needed to ensure final design elevations. The edges of in-water backfill areas will transition to blend with the surrounding bathymetry.

The anticipated sedimentation rates as presented in LimnoTech's assessment were incorporated in the estimates of the in-water backfill volumes required at each habitat restoration site. Because dredging is to occur in 2013–2014 and in-water backfill for habitat restoration is to occur the following year, the 5-year sedimentation rates provided in Table 1 of the assessment were used as the initial rates in the design. The sediment thickness likely to be deposited over the year was calculated for each site and subtracted from the volume of backfill required using the configuration assumptions stated above. Since a sedimentation rate was not available for the City Ship Canal site, a sedimentation rate was assumed by taking the median value of the 5-year sedimentation rates provided for the other sites.

Additional construction details are presented in the cross section in Drawing HD-4 (Appendix B). In-water backfill material specifications are provided in Appendix C. The technique will also be performed in some locations in conjunction with coir log placement, and SAV and EV planting.

2.3.1.2 Coir Logs for Emergent Vegetation Planting

Installation of coir logs will be implemented in locations where EV beds are to be created or enhanced. Coir logs consist of coconut fiber rolls placed with stakes and anchored by heavy individual stones placed parallel to the shoreline. The technique will be used to contain substrate placed along the shoreline in 3-foot-wide by 2-foot-deep beds for EV planting. The coir logs will provide a wave-break to lessen energy on the shore while EV is becoming established and is intended to be a temporary measure for retaining substrate until vegetation is established. In some locations, the technique will be used in conjunction with in-water backfill and rock vanes.

In this application, coir logs will be placed parallel to the shoreline starting at elevation 569 feet (2 feet below the average water surface elevation of 571 feet), and heavy stones will be placed over the coir logs to provide long-term anchoring of the coir logs. The 12-inch coir logs will be stacked such that the top of the coir log is at elevation 571 feet. The stones will also compress the coir logs at points along their length to provide multiple points for unrestricted water flow at times when water surface elevations are below 571 feet. A 6-inch layer of EV planting soil will be placed upslope of the coir logs at average water depths of 0 to 2 feet to provide substrate for EV establishment. The water depths were chosen to provide sufficient depths for EV to become established while discouraging invasive plant establishment. The area inside of the coir logs up through elevation 571 feet will then be planted with EV. Construction details are provided in Drawing HD-1 (Appendix B) and in the specification (Appendix C). EV planting soil specifications are included in the specifications and the technique will be performed in conjunction with EV planting.

2.3.1.3 Rock Vanes

Rock vanes will be constructed in conjunction with SAV and EV beds to dissipate wave energy, direct higher flows and debris away from SAV and EV beds, and encourage deposition of sediment behind the rock vanes, enhancing substrate, and providing a lower energy environment. The rock vanes are considered a hybrid of the standard rock vanes (which are flat and include rock up to bankfull elevations) and stone bendways, as they would follow the slope to an elevation of 571 feet.

Rock vanes will be trapezoidal in shape and will be constructed out of riprap. Rock vanes will extend from elevation 571 feet through the areas of EV and SAV plantings down to the elevation of 563 feet. The rock vanes will be keyed 10 feet into the bank to minimize the potential for scour. The rock vanes will be angled 30 degrees upstream to direct flow away from the bank and provide an area of deposition next to the shore portion of the downstream side of the rock vane.

Construction details are provided in Drawings HD-2 (Appendix B) and in the specifications (Appendix C). SAV planting soil specifications are included in the specifications.

2.3.1.4 Anchored Woody Debris

Use of anchored woody debris will be implemented to enhance aquatic habitat by providing cover and structure in the waterway, allowing fish to escape or rest when moving from one river segment to another, as well as providing cover and structural diversity for aquatic macroinvertebrates.

The technique consists of anchoring large woody debris to the river bed. Large woody debris will consist of White Oak logs or approved similar, angled 15 degrees upstream and anchored with a minimum of two Duckbill anchors. In an effort to not excavate material, anchors will be used to anchor large woody debris, as opposed to keying wood into the existing river banks. It is intended the logs be placed at the direction of the project engineer to adapt each placement to site-specific conditions.

The maximum design velocity identified at the restoration sites where either large woody debris or rootwads are to be installed (that is, Riverbend, Katherine Street Peninsula, and City Ship Canal) is 2.5 meters per second (m/s) (Table 1). Bioengineering guidance reports a maximum allowable flow velocity near rootwads (assumed to also be applicable to large woody debris) as 2.7 m/s (Allen and Leech 1997). Calculations of the buoyancy and drag forces that could be expected at the restoration sites using the assumed configuration, a maximum velocity of 2.5 m/s, and parameters identified in large woody debris design guidance (Shields et al 2002) are provided in Appendix D.

Based on the calculations, a minimum of two Duckbill anchors will be required for each large woody debris structure. In addition to anchors, boulders will be placed over and around the trunk portion of the anchored woody debris to provide both additional anchoring and to add structure to the waterway. Boulders will provide additional cover in the water and are intended to provide a factor of safety associated with the Duckbill anchors. Boulders will be a mix of 1 to 3 feet in diameter and 20 boulders per grouping of anchored woody debris will be placed. Specifications for the boulders can be found in Appendix C.

Additional details are provided in Drawing HD-3 (Appendix B) and specifications in Appendix C.

2.3.1.5 Rootwads

Rootwads are similar to the anchored woody debris, except rootwads are installed directly into backfill to provide fish habitat. The technique will be implemented only in the City Ship Canal, which includes backfilling for habitat restoration. The rootwads can be installed during backfill operations. For the City Ship Canal, rootwads will be installed along the slopes of the habitat islands that are being constructed. Note that rootwad placement will not occur in any of the material associated with the reactive cap material but is limited to backfill.

A rootwad will consist of White Oak log or approved similar, with a 4-foot-minimum-diameter fan placed so the entire root fan is submerged under water to a depth of 3 feet to allow small boat traffic above. Negligible drag forces were assumed due to extremely low velocities at the City Ship Canal site.

Additional details are provided in Drawing HD-2 (Appendix B) and in the specifications in Appendix C.

2.3.1.6 Soil Choking

Soil choking will be implemented, if needed, to provide additional substrate for aquatic vegetation in areas where riprap currently exists. It will also be implemented as part of the in-water work over the riprap at the Buffalo Color Peninsula. The technique consists of placing soil to fill in the voids between the existing riprap prior to the placement of the SAV/EV planting soil.

Soil choking will be achieved by using backfill, as needed, to fill in the voids between the riprap. Soil-choked areas within the in-water areas will be augmented with SAV/EV planting soils and will be planted with SAV/EV plant species.

Additional details are provided in Drawing HD-1 (Appendix B). In-water fill, SAV planting soil, and EV planting soil material specifications are provided in Appendix C.

2.3.1.7 Modified LUNKERS Boxes

A modified Little Underwater Neighborhood Keepers Encompassing Rheotactic Salmonids (LUNKERS) box is a shelf-like structure that provides cover for fish and aquatic macroinvertebrates below and a growing medium for SAV above. In this particular case, the design is based on an adapted LUNKERS box design modified to create submerged shelves that are anchored to existing sheet pile walls. The modified design provides cover for fish and aquatic macroinvertebrates and SAV growth media in an area where other restoration techniques are not suitable because of proximity of the navigation channel, channel depth, and desire to retain the existing sheet pile wall.

Modified LUNKERS boxes would provide resting and foraging areas for various fish species, such as steelhead/ rainbow trout and smallmouth bass, including pan fish and prey fish. With habitat generally lacking in the Buffalo River, fish species would be attracted to and will use the cover and vegetation. Modified LUNKERS boxes are intended to be demonstration projects and are not intended to be permanent structures. Wood was selected as the main construction material because when it does break free, it will degrade and blend with the natural environment, rather than create a hazardous obstruction or navigational risk.

Four modified LUNKERS boxes are proposed to be installed at Riverbend site, and three are proposed to be installed at the Ohio Street Shoreline site.

Modified LUNKERS box calculations for the beams, knee braces, bolts, angles, fasteners, and mount hangers are provided in Appendix D. Additional details are provided in Drawing HD-3 (Appendix B) and Specifications in Appendix C.

2.3.1.8 Supporting Techniques for Planting

The following subsections provide justification of details associated with the required elements of the various planting types.

Plant Choice. Selected plant choices (see specifications in Appendix C) consist of native species that are currently or were historically found in the Buffalo River watershed.

Care of Plantings. Care of the plantings will begin immediately after each planting is installed and accepted by the owner and will consist of keeping the plants in a healthy growing condition. All EV plantings will be watered once per week during the months of May through September. The contractor's warranty period shall be 2 years from the date of acceptance of the plants. Plants that are healthy (showing sprouting and leaf growth) and properly installed at the

time of final inspection will be accepted. For each of the restoration sites, the planting (SAV, EV) acceptance at the end of the 2-year period shall be based on 80 percent plant coverage. Annual monitoring shall be conducted by the contractor during the growing season (June to September). Based on the results of this monitoring, the contractor shall undertake the appropriate steps described in the specifications in Appendix C.

An additional 5-year establishment period will be provided for the plants, with monitoring of plant health, including species types, occurring on an annual basis and replanting efforts occurring as described in the Residual Monitoring Plan in Appendix H. These long-term monitoring efforts are not part of the contractor specifications and will be handled separately. Long-term care of plantings is included in the specifications in Appendix C.

2.3.1.9 Geese Exclusion

Animal exclusion methods will be used in conjunction with EV plantings. Geese exclusion will include staking, string, and flagging, with the specifics of the preferred exclusion method (for example, grid spacing, etc.) to be prepared by the contractor.

2.4 Planting Methods and Techniques

The following items are general assumptions made regarding planting methods and techniques associated with the habitat restoration:

- Removal of invasive SAV from the project sites is not part of this design. The only two sites where significant invasive SAV was observed are the Buffalo Color Peninsula and City Ship Canal sites, where additional fill is proposed to be placed that will impact the existing SAV, reducing the extent of the invasive SAV.
- EV and SAV materials will be provided as plugs. The need for pilot holes and anchor pins for SAV will be determined on a site-specific basis depending on site-specific conditions regarding wave action and sediment composition.
- Deciduous plant material will be planted and transplanted between April 15 and June 15. Actual planting will only occur when weather, soil, and river conditions are suitable for optimal benefit to the plant.

The following subsections discuss the components associated with each of the planting types and provide details for each of the listed components. EV and SAV planting schedules are included in specification in Appendix C. Specific locations of the planting types at the restoration sites are shown in Drawings RS-1 through RS-5 (Appendix B), with planting details displayed in Drawing HD-1 through HD-5.

2.4.1 In-water Planting Areas

The EV and SAV planting schedules in this design were shortened to focus more on wild celery (*Vallsineria americana*) for SAV and to limit the EV to species that have been observed in the Buffalo River AOC and in the watershed upstream. Wild celery is believed to be most beneficial for fish habitat; therefore, the preference is for wild celery dominance with a few additional species for diversity.

To limit the potential for SAV/EV plants to suffer from transplant shock due to low temperatures and frost conditions, planting in the spring will depend on the water temperatures in the Buffalo River. Water temperatures should be within 5 degrees of where the plant stock was harvested, with the river being a minimum of 42 to 44 degrees Fahrenheit. Additionally, to prevent planting during high flows and unsafe conditions, planting shall not occur during high-flow events and should only occur when the river sustains its mean water elevation for 2 to 3 days and there are no storms predicted during the next 7 days.

2.4.1.1 Emergent Vegetation Planting Areas

- Rock vanes or in-water backfill are shown in detail drawing HD-2 with cross sections on HD-4 (Appendix B).
- Coir logs construction details are shown in Drawing HD-1 (Appendix B) and provided in specifications in Appendix C.
- 6 inches of EV planting soil (specifications provided in Appendix C), based on results from previous field surveys regarding grain size and organic matter content of existing EV beds.

- Plant species from EV Plant Schedule (see specifications in Appendix C).
- Geese exclusion, consisting of twine and flagging strung between stakes at intervals so geese are discouraged from landing and browsing within EV planting areas.

2.4.1.2 Submerged Aquatic Vegetation Planting Areas

- Rock vanes or in-water backfill on shown on detail drawing HD-2 with cross sections in Drawing HD-4 (Appendix B).
- 6 inches of SAV planting soil (See specifications provided in Appendix C), based on results from previous field surveys regarding grain size and organic matter content of existing SAV beds.
- Plant species from SAV Plant Schedule (see specifications in Appendix C).

2.5 Habitat Restoration Design by Site

The restoration sites employ varying combinations of the above-referenced techniques to provide habitat value at each of the sites within specific site constraints and within the general design considerations listed in Section 2.1. Tables 2a through 2e list the restoration techniques to be implemented at each site. The tables were originally based on the preferred alternative documented in the FS report (ENVIRON et al 2010), and subsequently modified based on field observations and discussions with the PCT Habitat Subgroup.

The following sections provide rationale for the chosen restoration techniques, where additional information is warranted, and list site-specific assumptions that impact design choices and technique application at each site. Additional information regarding the origin of design choices at each site can be found in the EEE report (ENVIRON and MACTEC 2010). Site descriptions and an evaluation and summary of existing site conditions can be found in the habitat restoration data evaluation report (CH2M HILL and EEEPC 2011b).

2.5.1 Riverbend

Table 2a lists the proposed habitat restoration techniques at the Riverbend site. Design drawings for the proposed habitat restoration can be found in Drawings RS-1 and RS-2 (Appendix B).

The following assumptions/modifications have been made regarding the Riverbend site based on the proposed development and landowner input:

- Steel sheet pile wall along the downstream portion of the site will be left intact; however, the landowner has stated that it is available for minor modifications.
- The central sheet pile wall was investigated more closely and determined to be unsuitable for LUNKERS boxes, so the boxes were moved to the downstream sheet pile wall.

The following descriptions provide the rationale for individual design choices at the Riverbend site.

As discussed in Section 1.2.1, Buffalo Niagara Riverkeeper is currently completing a shoreline restoration design for the Riverbend site. Areas of SAV and EV planting were chosen based on existing bathymetry near the Riverbend site. Portions of the selected areas currently have broader shelves of appropriate depths for SAV and EV growth than other locations on the project site. SAV and EV planting, in conjunction with rock vanes, will occur in the upstream portion of the site.

Several areas, specifically the areas with natural sloped shorelines, will be augmented with anchored woody debris to provide in-water structure, stabilize proposed SAV and EV plantings, and encourage additional sediment deposition along the shoreline.

Three modified LUNKERS boxes will be installed along the downstream sheet pile wall. The central portion of this sheet pile wall currently lacks shallow habitat and has no overhang from the current tree canopy.

2.5.2 Buffalo Color Peninsula

Table 2b lists the proposed habitat restoration techniques at the Buffalo Color Peninsula site. The design drawing for the proposed habitat restoration can be found in Drawing RS-2 (Appendix B).

The following assumptions have been made regarding the Buffalo Color Peninsula site:

- Restoration activities will not disturb the underlying slurry wall beneath the existing riprap.
- The existing riprap is stable and no backfill is required following dredging.

The following descriptions provide the rationale for individual design choices at the Buffalo Color Peninsula site.

Based on the evaluation of the shoreline and in-water areas along this peninsula, it was determined that the riprap areas extend downward to elevation 563 feet. The remedial dredging activities along the peninsula are expected to start at a five feet offset from the edge of the riprap. Additionally, the riprap was assumed to be stable in the area and hence, no in-water backfilling will be required.

Soil choking will be employed at the Buffalo Color Peninsula site, primarily in the areas along the water's edge where riprap continues into the water for SAV/EV plantings. The technique is intended to provide additional media for plant growth without impacting the existing subsurface slurry wall below the riprap. The slurry wall is also the basis for plant choices at the site by not choosing plants with deeper root systems of tap roots. SAV and EV plantings in the area will occur in conjunction with soil choking (where needed) and rock vanes, depending on locations to be dredged and existing shallows that lack existing SAV, respectively.

Existing areas with broader shelves of appropriate depths for SAV and EV growth were selected for planting. Along the southern shoreline of the site, previous restoration activities have provided areas of shallow in-water habitat that currently has some minor EV established, but are relatively devoid of vegetation. The areas will be augmented with EV, including coir logs, in an effort to establish additional vegetation over a mostly barren area.

2.5.3 Katherine Street Peninsula

Table 2c lists the proposed habitat restoration techniques at the Katherine Street Peninsula site. The design drawing for the proposed habitat restoration can be found in Drawing RS-3 (Appendix B).

The following assumptions/modifications have been made regarding the Katherine Street Peninsula site based on landowner input:

- No work will be performed in the location of the future proposed boat launch (Drawing RS-3, Appendix B). The feature was located between existing larger willow trees and is estimated to be approximately 30 feet wide.
- The upstream parcel owned by Henry Olrogge is in the process of being upgraded with a water-dependent business. The central portion of the property will be converted to a boat lift and both docks and piers will be placed in the nearshore. SAV and EV will be planted on the small portion of nearshore habitat that will remain undisturbed by the proposed development.

The following descriptions provide the rationale for individual design choices at the Katherine Street Peninsula site.

The majority of the site will be planted with SAV and EV, with the exception of the two locations where planting is incompatible with future landowner uses. In-stream shallows will be expanded through most of the site by placing in-water backfill following remedial dredging activities. The site currently has SAV that observations indicate is limited by the existing appropriate depth contours in many locations. Particularly, upstream of the major site bend, there is an opportunity to expand the nearshore shelf with appropriate depths for SAV growth and not impact the navigation channel.

Rock vanes will be installed every 100 feet along the shoreline to augment sediment deposition and provide energy breaks.

The placement of anchored woody debris along the downstream half of the site was chosen because of the reduced hydrodynamic forces in this region allowing for greater sediment deposition and a greater likelihood that woody debris will remain fixed in place.

2.5.4 Ohio Street Shoreline

Table 2d lists the proposed habitat restoration techniques at the Ohio Street Shoreline site. The design drawing for the proposed habitat restoration can be found in Drawing RS-4 (Appendix B).

The following assumption/modification has been made regarding the Ohio Street Shoreline site based on landowner input: Existing features associated with the rowing club at the downstream portion of the site are to remain.

Due to the use of the inlet by the rowing club and impacts from the existing CSO, no habitat restoration activities will be conducted in the inlet. The following descriptions provide the rationale for individual design choices at the Ohio Street Shoreline site.

Field observations indicate that existing SAV at the Ohio Street Shoreline site is dominated by wild celery, but beds were limited by the amount of available area at the appropriate water depths because of a steep drop offshore of the existing beds. Two modified LUNKERS boxes will be installed along the downstream sheet pile wall, as the area currently lacks any shallow water habitat. Overhanging vegetation currently exists from the above tree canopy, but because this part of the site primarily faces southwest, it is assumed that there will be adequate light available for SAV growth associated with the modified LUNKERS boxes.

2.5.5 City Ship Canal

As discussed in Section 1.1, a chemical isolation cap will be placed in the City Ship Canal to isolate contaminants. A summary of the cap design is presented below, with additional details provided in Appendix D. The habitat restoration design has been integrated with the isolation cap design and presented as one set of drawings.

2.5.5.1 Capping

Capping was selected the FS as the remedial alternative to address the contaminated sediment in the tip of the City Ship Canal. The cap was designed specific to physical and chemical conditions of the area and using the procedures described by the USACE Waterway Experiment Station and USEPA guidance document (Palermo et al. 1998 a, b). Cap modeling to demonstrate long-term isolation from upward migration of contaminants used an analytical steady-state model from Lampert and Reible (2008), Version 1.18. Appendix D describes the cap design objectives, design considerations, capping material selection process, potential capping material sources, cap configuration, and cap placement methods.

In-water backfill in conjunction with the cap would be placed in the Ship Canal to establish the habitat elevations required for SAV and EV plantings (see below). To take advantage of the proposed placement of the backfill material that would be placed regardless of the cap, the analytical model was used to estimate the minimum cap thickness needed to achieve the cap design objectives. Based on the modeling, it was determined at least an 8.5 feet thick layer of backfill material would have to be placed. The proposed Ship Canal will include the following two types of caps: Backfill Cap and Reactive Cap. In areas where placed backfill thickness is greater than 8.5 feet, no additional reactive material would be placed and the backfill perform as a cap. In areas where the backfill thickness is less than 8.5 feet, a reactive cap with a thickness of 4 inches would be installed. Drawing RS-5 and HD-5 show the plan view and the cross-sectional views of the cap within the City Ship Canal.

2.5.5.2 Habitat Restoration

Table 2e lists the proposed habitat restoration techniques at the City Ship Canal site. The design drawing for the proposed habitat restoration site can be found in Drawing RS-5 (Appendix B).

The following assumptions have been made regarding the City Ship Canal site:

- The restoration design will be integrated with the cap design discussed in the previous subsection.
- The restoration site is outside of the navigation channel, so in-water fill placement is unrestricted.
- A deeper-water channel suitable for small boat access will be incorporated in the City Ship Canal restoration site design. A minimum 3-foot depth is required in the outer half of the restoration site to provide access for a rowing club regatta.

The following descriptions provide the rationale for individual design choices at the City Ship Canal site.

In-water backfill will be used to create a diversity of habitats by providing varying water depths in the Ship Canal. The existing bathymetry of the restoration site is relatively uniform and the water depths are generally too deep to provide appropriate depths for SAV growth except along the edges. A central channel (Channel at Top of Cap Depth; see Drawing RS-5, Appendix B) will be established through the in-water fill to maintain access for recreational boats and to continue to provide some deeper water fish habitat areas adjacent to the proposed shallower areas of in-water fill. Starting at the elevation of the central channel, in-water backfill will be placed at an approximate 3:1 slope to a water depth of 8 feet below the average water surface elevation. A strip approximately 10 feet wide

will be graded to an elevation of 563 feet and planted with SAV around the entire site. SAV will be planting along the 3:1 slope from elevation 563 feet to 569 feet as well. In-water slopes will be 3:1 or flatter to provide low enough angles that sloughing concerns will be limited. Additional fill will be used to create four fish habitat islands (see RS-5 and HD-5 for plan view and details) to further diversify underwater bathymetry and rootwads will be placed in the fill for the habitat islands to further provide structural diversity. The upper elevation of the fish habitat island features will remain 3 feet below the average water surface elevation so as not to create additional attractions for geese, while allowing outboard motor boat traffic above. The top 1 foot of the 4 islands will consist of gravel substituted for the surface backfill material to provide spawning substrate. The northern edge of the in-water backfill will slope down at 3:1 to the appropriate elevation at the edge of the navigation channel.

The head (southern portion) of the restoration site will be filled to final elevation of 569 feet and planted with EV, which will then slope up to the average water surface elevation at 571 feet. An additional strip, approximately 5 feet wide, will be graded to an elevation of 569 feet and planted with EV around the entire site to supplement vegetative diversity. No coir logs will be used for the additional strip of EV plantings because the site is outside of the navigation channel and wave action is anticipated to be minimal. Also, flow in this portion of the AOC is limited because the Ship Canal is analogous to a blind slough with little to no surface water inputs.

In general, debris will be disposed of offsite in an appropriate landfill. Metal debris may be sent to a recycling facility if suitable. Minor amounts of metal debris will be removed from the water approximately between stations 855+00 to 858+00 on the western side of the site. The adjacent in-water wood structure will remain in place. The metal will be removed as it is a nuisance and will impede installation of the chemical isolation cap. The adjacent wood piling structure will be retained to the extent possible as it provides valuable structure in the water.

See cross sections in Drawing HD-4 (Appendix B) for sections through the restoration site.

SECTION 3

Habitat Restoration Design Implementation

Section 3 discusses the proposed or potential design implementation approaches. It should be noted that some elements of the design are conceptual with the intent that details will be proposed by the contractor to achieve performance requirements described in the specifications. Bidders for the contract will be required to provide a general description of their qualifications, proposed site layout, equipment, and procedures, so significant proposed modifications can be discussed and evaluated prior to the award of the contract. In addition, before starting the work, the contractor will be required to provide a detailed work plan that will lay out the specifics of the proposed habitat restoration activities. The work plan will be provided to members of the PCT for review and approval. The contract plans and specifications describe the functional requirements and procedures for these items.

3.1 Working Season and Hours of Operation

It is anticipated most activities will be performed a minimum of 5 days per week (Monday through Friday) during normal daylight hours. The weekend will be reserved for maintenance work or to compensate the downtime incurred during the work week.

Mobilization for the habitat restoration work is anticipated to start in 2013 (refer to the construction schedule in Appendix E). The permissible environmental windows for water activities are June 15 through December 30 for the Buffalo River and July 1 through December 30 for the City Ship Canal (USACE 2010b); however, activities are assumed to not extend past the end of November due to typical adverse weather conditions. Contaminated sediment dredging and capping activities are anticipated to start in 2013 and continue into 2014 with select habitat restoration activities occurring in conjunction with sediment remediation activities, and the majority of the habitat restoration activities expected to occur in the 2014 and 2015 construction seasons.

3.2 Minimizing Environmental and Public Impacts

Environmental and public impacts will be minimized during habitat restoration activities through proper permitting and planning during the design phase, as well as adherence to environmental controls and monitoring during the execution of the project.

3.2.1 Planning and Permitting

The following items related to planning and permitting will be completed:

- Joint Permit Application which incorporates requirements of Section 10 of the Rivers and Harbor Act of 1899, Section 404 of the Clean Water Act (CWA), and Section 401 of the CWA (prepared by CH2M HILL).
- Preparation of a Full Environmental Assessment Form and an Environmental Assessment of the project in accordance with 6 New York Code, Rules and Regulations (NYCRR) part 617 State Environmental Quality Review (SEQR) (prepared by CH2M HILL).
- Determination if an endangered and threatened species consultation and/or review and cultural resources review are required (performed by CH2M HILL).
- Determination if migratory birds could be impacted by construction of restoration projects and if so, development of measures to comply with the Migratory Bird Treaty Act (performed by CH2M HILL). Determination of applicability of the Bald and Golden Eagle Protection Act and measures to be taken for compliance (performed by CH2M HILL).
- Coordination with the U.S. Coast Guard regarding a Notice to Mariners (to be prepared by the GLNPO contractor).
- Preparation of a stormwater pollution prevention plan in accordance with the State Pollutant Discharge Elimination System (SPDES) General Permit for Construction Activity (to be performed by GLNPO contractor). There are no specific local (city or county) requirements beyond those covered by the SPDES.

- Characterization and suitability determination of maintenance dredge material for beneficial reuse for habitat purposes. If material is suitable, a new additional permit will be required and prepared through coordination with USACE and NYSDEC (to be prepared by USACE and NYSDEC).
- A temporary building permit will be required for any support structures. The City of Buffalo will require a survey, a site plan, and a description of the type and configuration of any structures to be erected as part of the application (to be prepared by GLNPO contractor).
- Significant floodplain modifications are not anticipated as part of this project; however, the final design will investigate the need for any floodplain permits associated with the filling and capping, temporary mooring facilities, offloading areas, and minor modifications to existing bathymetry (performed by CH2M HILL).
- According to USACE, no wetlands were found in the proposed project area (USACE 2010a); hence, no wetland permits are needed for this project.

3.2.2 Execution of Habitat Restoration Activities

Project information will be communicated to local property owners, municipalities, and general members of the public throughout the design phase and during the habitat restoration activities to help limit adverse impacts of the project to residents and commercial entities.

Impacts to water quality from the habitat restoration activities will be minimized by implementing best management practices (BMPs), as described in Section 3.3.3, and by complying with conditions that may be imposed as part of the Joint Permit including a 401 Water Quality Certification.

3.3 Construction Activities

Prior to mobilization to the site, the contractor will verify the necessary permits have been obtained and the habitat restoration work is in compliance with permit requirements. The contractor will deliver necessary preconstruction submittals to the owner's representative for approval before mobilization. The owner's representative will forward relevant submittals to the PCT for concurrent review. The contractor will complete a preconstruction survey prior to starting any habitat restoration activities.

3.3.1 Mobilization and Site Preparation

Mobilization and setup of equipment likely will be performed concurrently with site preparation activities. The site preparation and mobilization activities will include, but not be limited to, the following:

- Mobilization of equipment and personnel
- Limited clearing and grubbing of vegetation, if necessary, and implementation of erosion control measures in staging/stockpile areas
- Establishment of physical construction limits with temporary fencing around staging areas
- Placement of project identification signs at the entrance to each of the restoration sites and staging areas
- If desired by the contractor, setup of a site trailer and utility connections
- Construction of temporary infrastructure at the staging areas
- Notification to U.S. Coast Guard (Notice to Mariners)

3.3.2 Temporary Access and Staging/Stockpile Areas

Site access is expected to be primarily by the river by barge, but may be available by land at all of the restoration sites, if landowner access agreements can be obtained by the contractor. For land access to the restoration sites and as necessary, temporary access roads may need to be constructed or improved to support heavy equipment access, provide structural stability, and minimize the tracking of loose soil from the existing access roads onto public roadways by trucks. Once the existing surface is leveled and prepared, a geosynthetic fabric will be laid to separate and stabilize the foundation. An aggregate layer will be placed and compacted over the geosynthetic fabric. Following

construction, the access roads will be fully decommissioned and the areas restored to their preconstruction conditions, or as otherwise determined based on landowner-contractor agreements.

To the extent practicable, the contractor will use the barge docking structure, temporary access roads, and/or staging/stockpile areas established during the sediment remediation activities, and return the areas to existing conditions following construction, or as otherwise determined based on landowner-contractor agreements.

3.3.3 Best Management Practices and Temporary Erosion and Sediment Control

BMPs and temporary erosion and sediment controls will be implemented throughout habitat restoration activities to minimize any adverse impacts to the environment during the performance of the work. Air pollution will be minimized by wetting down disturbed areas and properly operating and maintaining construction vehicles and equipment.

The following stabilization measures will be employed throughout construction at the restoration sites: sequencing, seeding, installation of erosion control blankets and coir logs, and preservation of vegetation where possible.

The contractor will provide temporary erosion control measures such as silt fences, berms, and straw bales around work areas and fill material stockpile areas to prevent contaminant migration. Stockpiles will be covered.

BMPs are discussed in specifications in Appendix C.

3.3.4 Equipment and Methods

The in-water habitat restoration activities are to be conducted by barge using heavy equipment such as an excavator and crane with a clamshell bucket. SAV planting and several in-water mechanical installation methods (for example, installing LUNKERS and anchors for anchored woody debris) will be conducted by dive crews. Some of the activities (for example EV, coir logs, and rock vanes) can be conducted by land at all of the restoration sites, if landowner access agreements can be obtained by the contractor. If land access is obtained, the contractor shall follow the procedures described in Section 3.3.2 and in the specifications in Appendix C.

3.3.5 Schedule and Sequencing

The final construction schedule is included in Appendix E. Sediment remediation activities are scheduled to take place in the 2013 and 2014 construction seasons. In-water backfill will be placed in the fall of 2013 to allow settling to occur over the winter, and rootwads will be installed at the City Ship Canal in conjunction with in-water backfill placement. A post-backfill placement bathymetric survey will be performed in the fall of 2013 to document the in-water backfill depths. A pre-planting bathymetric survey will be performed in the spring of 2014 to ensure appropriate depths for SAV and EV planting, and additional in-water backfill will be placed if necessary. Following the in-water backfill placement, anchored woody debris, rock vanes, and modified LUNKERS will be installed in the 2014 construction season. Following that, coir log placement and SAV and EV plantings will occur during the planting window in the 2014 construction season. Once the restoration activities have been completed and accepted by the owner's representative, the Contractor's 2-year warranty period will commence. Planting maintenance will be ongoing for 2 years during the warranty period.

SECTION 4

Compliance with Applicable Requirements

The following sections provide a list of applicable requirements for habitat restoration activities, identify and summarize the relevant federal and state environmental permitting laws and regulations, and establish how the design will satisfy the requirements of the laws and regulations.

4.1 Clean Air Act

The Clean Air Act (CAA), 40 *Code of Federal Regulations* (CFR), Parts 50 through 99, is intended to protect the quality of air and promote public health. Title I of the act directs USEPA to publish national ambient air quality standards for "criteria pollutants." The National Ambient Air Quality Standards, Section 109, provides specific requirements for air emissions including, but not limited to, particulates, volatile organic compounds, and hazardous air pollutants. USEPA also has provided national emission standards for hazardous air pollutants under Title III of the CAA. Hazardous air pollutants are designated hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act. The CAA amendments of 1990 greatly expanded the national emission standards for hazardous air pollutants by designating 179 new hazardous air pollutants and directing USEPA to attain maximum achievable control technology standards for emission sources. Such emission standards are potential requirements for remedial actions producing air emissions or regulated hazardous air pollutants.

No state or federal permit is required for the proposed habitat restoration activities, although best practices to control dust will be implemented. Best available practices will be used, as necessary, to control potential particulate emissions. Air monitoring will be implemented in accordance with New York State Department of Environmental Conservation Technical Guidance for Site Investigation and Remediation, DER-10 Appendix 1A, New York State Department of Health Generic Community Air Monitoring Program (May 2010).

4.2 Clean Water Act

The CWA, 33 United States Code (USC) §1251 to 1376 and 33 CFR, Part 323, provides regulations for the discharge of pollutants into the waters of the United States. It requires USEPA to set water quality standards for all contaminants in surface waters, and requires that permits be obtained for discharging pollutants from a point source into navigable waters such as the Buffalo River. The CWA is also triggered by activities such as filling for restoration, which are part of the restoration activities.

Regulations promulgated under the authority of the CWA require permits for placement of fill in navigable water. The applicable permits include the Section 404 permit, authorized by the USACE, and the Section 401 Water Quality Certification issued by NYSDEC. A Section 401 certification is necessary for all projects requiring a Section 404 permit and is part of the Section 404 permit review process. Because Buffalo River is designated as a navigable waterway, the requirements and conditions of the Section 404 permit and Section 401 certification will be met. Typical requirements include actions to minimize resuspension of sediments and erosion control during habitat restoration activities. The New York State Division of Water Technical and Operational Guidance Series (5.1.9), In-water Management of Sediment and Dredged Material, were considered in the project design. Attainment of both the Section 404 permit and the Section 401 certification will be completed through submission of NYSDEC's Joint Permit Application Form. According to USACE, no wetlands have been located in the project area; thus, no wetlands permit is required.

4.3 Federal Water Pollution Control Act and State Pollutant Discharge Elimination System

Section 402 of the Federal Water Pollution Control Act (FWPCA), 33 USC §1342, allows USEPA to authorize NYSDEC to issue permits and establish requirements for "point source" discharges from facilities or activities that will generate wastewater or stormwater. Through Section 402, NYSDEC regulates such discharges through the SPDES NYCRR Subpart 750. The SPDES program regulates discharges to both groundwater and surface waters. Additionally, SPDES

permits for discharges are required to include effluent limits and conditions while also taking into account available technology for the treatment of such wastewater/stormwater and applicable water quality standards.

While the habitat restoration activities are not expected to qualify as a "point source" for direct discharges of wastewater/stormwater in accordance with FWPCA and SPDES regulations, upland disturbances of at least 1 acre for habitat restoration activities could occur if the contractor accesses the habitat restoration sites from the land by obtaining landowner access agreements. If so, the requirements for a SPDES General Permit (GP-02-01) for construction activities will be met, including the development of a stormwater pollution prevention plan. The stormwater pollution prevention plan will be prepared in accordance with the technical standards within NYSDEC's New York Standards and Specification for Erosion and Sediment Control, which mandates the required contents of the plan and sampling/inspection of any stormwater controls at a construction site.

4.4 Rivers and Harbors Act

Section 10 of the Rivers and Harbors Act of 1899, 33 USC §401 et seq. and 33 CFR, Parts 403 and 322, prohibits unauthorized excavation or fill within the limits of the navigable waters of the United States.

Habitat restoration work is being coordinated with USACE regarding project requirements and notifications for work that could affect the navigational channel. USACE has authority under Section 10 to grant a Nationwide Permit 38, which will be applied for under New York's Joint Permit Application Form. NWP Permit 38 addresses navigation notices, aquatic life movements, spawning areas, migratory bird breeding areas, suitable material, water supply intakes, fills within 100-year floodplains, soil erosion and sediment controls, management of water flows, proper maintenance, wild and scenic rivers, tribal rights, endangered species, historic properties, designated critical resource waters, and mitigation water quality among other topics.

Typical requirements to be met for backfilling within a navigable waterway include measures to minimize resuspension of sediments and erosion of sediments and stream banks. The habitat restoration work will be performed in a manner that meets the requirements of Section 10 of the Rivers and Harbors Act.

4.5 Endangered Species Act

The Endangered Species Act of 1973, 16 USC §1531 et seq. and 15 CFR, Part 930, requires federal agencies ensure any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify critical habitat. Correspondence from the New York State Nature Heritage Program identified 15 rare species that are known to currently persist in the project area, 5 of which are listed as threatened or endangered (see the following table). None of the species is federally listed.

Natural Heritage Report on Rare Species

Common Name	Scientific Name	NYS Legal Status	Area
Birds			
Peregrine falcon	*Falco peregrinus*	Endangered	Project vicinity
Least bittern	*Ixobrychus exilis*	Threatened	Project vicinity
Pied-billed grebe	*Podilymbus podiceps*	Threatened	Project vicinity
Common tern	*Sterna hirundo*	Threatened	Project vicinity
Fish			
Black redhorse	*Moxostoma duquesnei*	Special Concern	Buffalo River
Freshwater Mussels			
Fragile papershell	*Leptodea fragilis*	Unlisted	Buffalo River
Pink heelsplitter	*Potamilus alatus*	Unlisted	Buffalo River

Based on the location of habitat restoration activities that will be conducted within the Buffalo River, it is not anticipated that critical habitats will be affected. To comply with the requirements, USEPA will consult with NYSDEC to obtain concurrence that no critical habitat will be adversely affected during implementation of the habitat restoration activities.

USFWS will be consulted regarding federally protected threatened and endangered species in the project area, including verifying compliance with the Bald and Golden Eagle Protection Act. Details regarding federally listed species that may be present in the project area will be identified in the final design process. USFWS will also be consulted regarding the Migratory Bird Treaty Act, and the compliance and applicability will be determined as part of the final design process.

4.6 National Historic Preservation Act

The National Historic Preservation Act (NHPA), 16 USC §661 et seq. and 36 CFR, Part 65, establishes procedures for preserving scientific, historical, and archaeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program. Within New York State, NHPA requirements, as well as those authorized under the New York State Historic Preservation Act of 1980, are administered by the State Historic Preservation Office.

Prior to undertaking any habitat restoration activities, the State Historic Preservation Office will be contacted to determine the potential for the activities to disturb or impact any significant archaeological resource. If it is found that a potential impact to cultural or archaeological resources exists, then a cultural and archaeological resource assessment will be performed so that the activities comply with the requirements of NHPA. Review will be performed in conjunction with SEQR (Section 4.7).

4.7 State Environmental Quality Review

In New York State, most projects or activities proposed by a state agency or unit of local government, and all discretionary approvals (permits) from a New York State agency or unit of local government, require an environmental impact assessment as prescribed by 6 NYCRR Part 617 SEQR. SEQR requires the sponsoring or approving governmental body to identify and mitigate the significant environmental impacts of the activity it is proposing or permitting to land, air, plants and animals, water quality historical or archeological resources, and the potential for the project to create noise and odor impacts. The Buffalo River habitat restoration project will require permits from New York State and is subject to SEQR. The SEQR process for restoration will be initiated upon PCT acceptance of the design and in conjunction with the sediment remediation. The initial SEQR submittal will include the Long Environmental Assessment Form with an attached environmental assessment describing the potential impacts of the dredging project and the restoration work. It will also include the results of consultations with the U.S. and New York State Fish and Wildlife Services and State Historic Preservation Office.

4.8 Beneficial Reuse Materials

Beneficial reuse material originating from maintenance dredging in the Buffalo River as identified by USACE may be used as backfill for habitat restoration. The potential source areas for this material are located in the upstream section of the Buffalo River. Currently, USACE and NYSDEC are discussing the use of such material and the required chemical testing for characterization purposes. Chemical characterization is ongoing, and the results are not available in time to be presented as part of the design phase. A determination of suitability will be performed by USACE, at which point a determination of material use will be made, and if needed the permit for using beneficial reuse material will be obtained.

4.9 OSHA Requirements

A health and safety plan for construction and remedial activities in accordance with the Occupational Safety and Health Administration (OSHA) requirements listed in 20 CFR 1910 and 20 CFR 1926 will be required prior to undertaking any remedial action.

4.10 Local Notice to Mariners

The U.S. Coast Guard publishes Local Notice to Mariners as a means of distributing information regarding impacts or disturbances to navigable waters, including impacts to aids to navigation, hazards to navigation, and other items of interest. U.S. Coast Guard standards will be used for any markings associated with the project. Due to the proximity of the habitat restoration activities to the navigation channel within the Buffalo River and additional construction-related boat traffic, a Local Notice to Mariners will be issued through the U.S. Coast Guard's Navigation Center once the schedule for habitat restoration activities is known more precisely.

4.11 Building Permit

A temporary building permit will be required for construction of project support structures. The City of Buffalo will require a survey, a site plan, and a description of the type and configuration of structures that will be erected as part of the permit application.

SECTION 5

Performance Monitoring

Section 5 provides a brief summary of the performance monitoring requirements for the habitat restoration activities.

5.1 Construction Monitoring

Construction monitoring will include contractor oversight and verification of construction of the designed features. A key element to successful construction of habitat restoration features is detailed construction oversight, particularly during placement of structural elements. Additional construction monitoring will include verifying material types, placement techniques, and conformance with specifications.

5.2 Post-construction Monitoring

Post-construction, long-term monitoring typically begins with the establishment of specific performance goals for each of the design features. Site monitoring then occurs over multiple years and includes documenting site conditions such as structural integrity of placed material, plant growth and success, and fish, invertebrate, and wildlife community use of the restoration sites. The data are compared to baseline information to determine overall remedy effectiveness and to determine if additional measures are required to meet performance goals. Details regarding identification and specification of performance measures are provided as part of the Residual Monitoring Plan provided in Appendix H.

A plant establishment period, however, will be implemented to increase the success of establishing native communities of EV and SAV plants. This step will take the form of adaptive management to augment plant mortality and control invasive species. The contractor shall warranty all plant material installed under this Contract for a period of 2 years from the date of final acceptance of the installed plants. For each of the restoration sites, the planting (SAV and EV) acceptance at the end of the 2-year period shall be based on 80 percent plant coverage. Annual monitoring shall be conducted by the contractor during the growing season (June to September). During monitoring, percent cover and species composition at each of the restoration sites shall be measured. Based on the results of the monitoring, the plants shall be replaced in accordance with the specifications (Appendix C), no later than the following growing season (June to September), at the Contractor's expense.

After the initial contractor planting guarantee, a continued base period will include monitoring, replanting, and maintenance to ensure vegetative establishment through year 5. Assessment of plant conditions will be conducted annually to assess the conditions of the planting areas (plant mortality, species of survival, etc.). During years 3 through 5, replanting and/or maintenance, including additional invasive plant removal, will occur as needed based on assessment observations (this work is not part of the contractor's responsibility). Further details are provided in the specifications (Appendix C) for the 2-year monitoring and the Residual Monitoring Plan (Appendix H) for the 3- to 5-year monitoring.

SECTION 6

Construction Schedule

The construction schedule is provided in Appendix E.

SECTION 7

Biddability and Constructability Review

The project review team has reviewed this BODR Volume 2, and comments were incorporated as appropriate. Staff members from CH2M HILL's affiliate, CH2M HILL Constructors, Inc., reviewed the BODR with an emphasis on biddability and constructability.

SECTION 8

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Tables

TABLE 1

Design Flows, Velocities, and Shear Stresses

Habitat Restoration BODR Buffalo River AOC, Buffalo, New York

Site Name	Approximate Site Location	Selected Design Flow	Design Velocity (cm/sec)	Design Shear Stress (dynes/cm^2)	Design Considerations
Riverbend	Upper (LDB, RM 5.5 to 5.8)	High flow, 10-year flood	250	40	Potential scour area at upstream boundary (RM 5.8)
	Middle (LDB, RM 5.0 to 5.5)		150	10	Sediment deposition potential
	Lower (LDB, RM 4.7 to 5.0)		60	5	Sediment deposition potential
Buffalo Color Peninsula	RDB, RM 4.5 to 5.1	High flow, 10-year flood	150	10	Two potential scour areas: (1) in upstream portion (RM 5), and (2) immediately downstream of the tip of the peninsula (RM 4.7)
Katherine Street Peninsula	Upper (RDB, RM 3.5 to 3.7)	High flow, 10-year flood	150	20	Potential scour area (RM 3.5 – 3.7)
	Lower (RDB, RM 3.3 to 3.5)		125	10	Potential scour area immediately downstream of RM 3.5
Ohio Street Shoreline	RDB, RM 1.7 to 1.8	Low flow, high seiche	270	60	No potential scour areas
City Ship Canal	End of canal	Low flow, high seiche	N/A	N/A	No potential scour areas

cm/sec = centimeters per second

dynes/cm^2 = dynes per square centimeter

RM = river mile

TABLE 2a

Restoration Techniques for the Riverbend Site

Habitat Restoration BODR Buffalo River AOC, Buffalo, New York

Restoration Technique	Type[(1)]	Quantity	Units	Notes
Submerged Aquatic Vegetation Planting	In-water	0.48	Acres	Planted in conjunction with rock vanes and anchored wood in some cases.
Emergent Vegetation Planting	In-water	0.85	Acres	Upstream portion of site.
Rock Vanes	In-water	7	Each	Along the shoreline in conjunction with SAV and EV planting to augment sediment deposition and provide wave breaks.
Anchored Woody Debris	In-water	14	Each	Upstream portion of site, out of navigation channel.
Modified LUNKERS Boxes	In-water	4	Each	Along downstream sheetpile wall.
Riparian Planting Type 1	Riparian	0.23	Acres	In areas under existing tree canopy.
Riparian Planting Type 2	Riparian	0.03	Acres	In areas under existing tree canopy.

(1) In-water techniques are included as part of the GLLA project. Riparian techniques are part of the design for future projects.

TABLE 2b

Restoration Techniques for the Buffalo Color Peninsula Site

Habitat Restoration BODR Buffalo River AOC, Buffalo, New York

Restoration Technique	Type[(1)]	Quantity	Units	Notes
Submerged Aquatic Vegetation Planting	In-water	0.62	Acres	Planted in conjunction with rock vanes and with in-water backfill.
Emergent Vegetation Planting	In-water	1.26	Acres	Planting emergent vegetation in existing shallows that lack vegetation and to augment existing EV. Also in conjunction with in-water backfill.
Rock Vanes	In-water	9	Each	Along the shoreline in conjunction with SAV and EV planting to augment sediment deposition and provide wave breaks.
Riparian Planting Type 3	Riparian	2.50	Acres	Planting vegetation to augment soil choking in existing riprap.

(1) In-water techniques are included as part of the GLLA project. Riparian techniques are part of the design for future projects.

TABLE 2c

Restoration Techniques for the Katherine Street Peninsula Site

Habitat Restoration BODR Buffalo River AOC, Buffalo, New York

Restoration Technique	Type[(1)]	Quantity	Units	Notes
Submerged Aquatic Vegetation Planting	In-water	1.02	Acres	Majority of length of site, except upstream portion and in front of proposed future boat launch.
Emergent Vegetation Planting	In-water	0.14	Acres	Majority of length of site, except upstream portion and in front of proposed future boat launch.
Rock Vanes	In-water	9	Each	Along the shoreline in conjunction with SAV and EV planting to augment sediment deposition and provide wave breaks.
Anchored Woody Debris	In-water	8	Each	Outside of navigation channel, intended to provide structure in the water.
Riparian Planting Type 2	Riparian	0.80	Acres	In-fill plantings under existing tree canopy.
Riparian Planting Type 4	Riparian	0.28	Acres	Plantings in the vicinity of fascines, similar to Riparian Type 1 planting at half density.

(1) In-water techniques are included as part of the GLLA project. Riparian techniques are part of the design for future projects.

TABLE 2d

Restoration Techniques for the Ohio Street Shoreline Site

Habitat Restoration BODR Buffalo River AOC, Buffalo, New York

Restoration Technique	Type[1]	Quantity	Units	Notes
Submerged Aquatic Vegetation Planting	In-water	0.03	Acres	Planted along the upstream side of the inlet.
Emergent Vegetation Planting	In-water	0.05	Acres	Planted along the upstream side of the inlet.
Modified LUNKERS Boxes	In-water	3	Each	Along downstream sheetpile wall.
Riparian Planting Type 1	Riparian	0.04	Acres	Along the downstream side of the Inlet or where invasive vegetation is dominant.
Riparian Planting Type 2	Riparian	0.28	Acres	In-fill plantings under existing tree canopy.
Riparian Planting Type 3	Riparian	0.04	Acres	Planting vegetation to augment soil choking in existing riprap.

(1) In-water techniques are included as part of the GLLA project. Riparian techniques are part of the design for future projects.

TABLE 2e

Restoration Techniques for the City Ship Canal Site

Habitat Restoration BODR Buffalo River AOC, Buffalo, New York

Restoration Technique	Type[(1)]	Quantity	Units	Notes
Submerged Aquatic Vegetation Planting	In-water	2.04	Acres	In areas with an elevation greater than 563 and less than 569.
Emergent Vegetation Planting	In-water	1.27	Acres	At head of Ship Canal and on backfill created 5' wide bench feature around perimeter.
Rootwads	In-water	13	Each	Placed in conjunction with in-water fill.
Anchored Woody Debris	In-water	5	Each	Place along the eastern side of the Ship Canal for habitat diversity.
Riparian Planting Type 1	Riparian	0.90	Acres	In areas where concrete coating will be removed from the bank or where invasive vegetation is dominant.
Riparian Planting Type 2	Riparian	1.34	Acres	In-fill plantings under existing tree canopy or where significant native vegetation already exists.

(1) In-water techniques are included as part of the GLLA project. Riparian techniques are part of the design for future projects.

Figures

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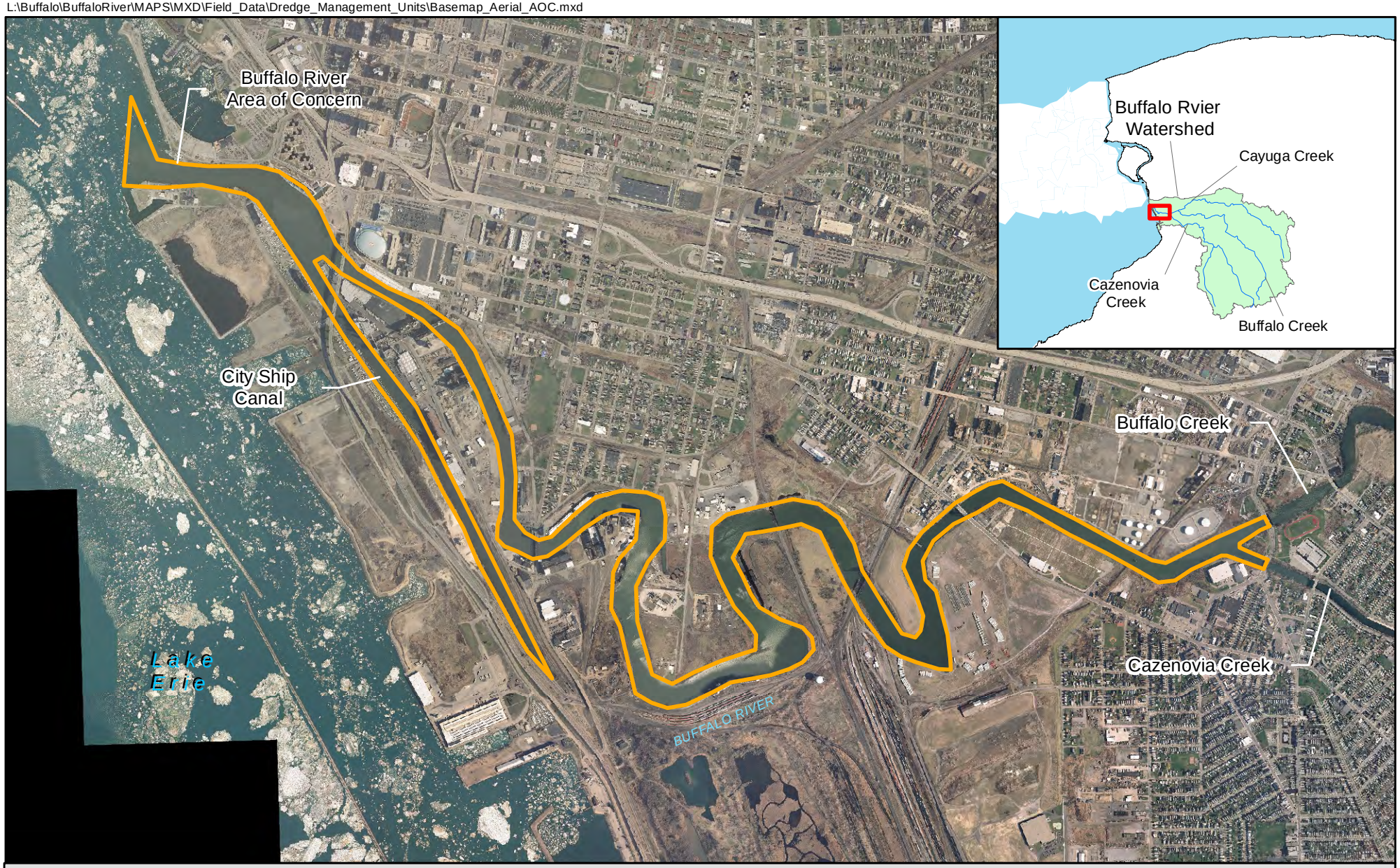

Figure 1
Site Location Map
Buffalo River AOC Remedial Design
Buffalo, New York

0 250 500 1,000 1,500 Feet

Navigation Channel
Stationing Line
River Mile
Habitat Restoration Site
Habitat Restoration Areas/Mitigation Sites

Figure 2 Habitat Restoration Site Locations Map
Western Portion
Buffalo River AOC Remedial Design
Buffalo, New York

0 250 500 1,000 1,500 Feet

Navigation Channel
Stationing Line
River Mile
Habitat Restoration Site
Habitat Restoration Areas/Mitigation Sites

Figure 3 Habitat Restoration Site Locations Map
Eastern Portion
Buffalo River AOC Remedial Design
Buffalo, New York